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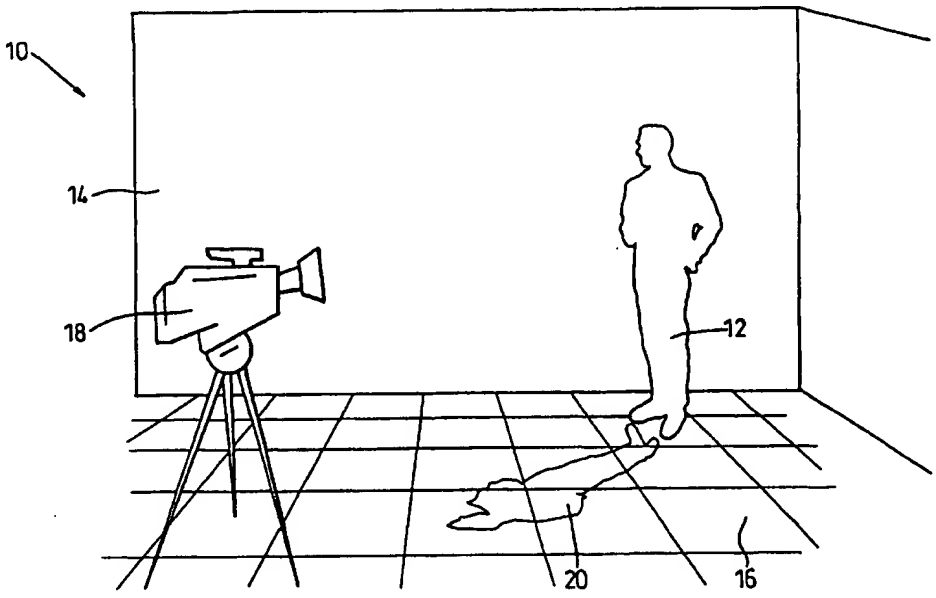

(57) Abstract

An artificial reflection of an actor or foreground object is created by imaging the actor by a video camera, calculating the position of the actor relative to the video camera and transforming the image of the actor when considered as a two dimensional planar image into a reflection in a selected plane different to that of the actor or object, said selected plane being a "ground" plane in a combined image.

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METHOD AND APPARATUS FOR CREATING ARTIFICIAL REFLECTION

The present invention relates to a method and apparatus for creating artificial reflections and more particularly for creation of artificial reflections in virtual studio and blue screen productions.

Virtual studio technology comprises systems which separate actors or objects from their background by keying the actors or objects from the background according to various parameters including chroma keying, distance keying and other keying techniques. Keying the foreground actors or objects from the background enables the integration of the foreground actors or objects with a different background, thereby enabling the production of a much more complex background.

There are many examples in television production, where live foreground video images, keyed by using chroma-key technology are combined with previously prepared and stored background images. A chroma key studio is characterised by special walls, having a unique mono colour or a selection of distinct colours. The actors or the objects are placed in front of the coloured walls. The overall image is processed by a chroma keyer, that separates according to colour difference the actors or objects placed in the studio, from the studio walls and produces a foreground image.

The Chroma keyer also combines the foreground image with the preferred background image to produce the output image.

There are other techniques to separate foreground actors and objects from their background, one of them is distance keying. With Distance technology, for each pixel in the image a depth measurement is performed. By defining a threshold distance it is possible to distinguish between foreground actors and objects and the rest of the background, thus creating a foreground and a background images.

When performing a simple integration of the foreground image with the background image, the integrated image looks unrealistic especially concerning the lighting and reflection conditions. Due to the fact that the foreground image and the virtual background image are taken from two separate sources, the lighting conditions are generally unmatched. This is particularly true when dealing with the foreground actors and objects reflections, that have to take into account the camera position and orientation related to the preferred actors or objects.

Reflections presented in a video scene are an integral part of realistic imaging. In a normal image the reflection image captured by the camera is a result of light originated from foreground objects, then reflecting on a reflective surface toward the camera. Due to this specific trajectory of the light ray, object's reflections are always oriented toward the camera, with shape that depends on the object distance from the camera, the camera position, the camera viewpoint and the amount of light originated from the object.

The current method for creating reflections in a virtual studio is to place a real reflecting surface that enables the introduction of the reflection image. This technique is cumbersome and limits the production's possibilities. In case of chroma key studio it also reflects colour from the

studio walls and floor onto the actors and objects, causing a much more difficult chroma key separation.

Another problem related to the current method for reflection is to cast reflection on additional object positioned in front of the foreground actors and objects, or part of the background image placed in front of the foreground actors and objects. In that case, the reflected image can not be placed in a proper way since it was constructed upon a different surface geometry.

It is an object of the present invention to provide a system and method for producing a two-dimensional video image with artificial reflection in real time. The invention pertains generally to any video scene and particularly to virtual studio systems including real and virtual videos that comprises background and foreground objects and images. The present invention proposes a dedicated technique to produce reflections for any object in the scene, given its position in the scene.

The above mentioned problems, relating to introducing reflections in a chroma keying environment and other problems are addressed by the present invention. The present invention will be understood by reading the following specification. A system and method is described for creating artificial reflections of foreground objects.

In particular, the present invention describes a system design of a chroma keying system, positioning system for any foreground object, camera parameters (x,y,z position, pan, roll, tilt, zoom, aspect ratio) capturing system for every studio camera. The generated reflections will

follow both object movements in the scene and the camera movements, resulting in an high quality look of the integrated image.

A system is also described where the reflection can be reflected from the studio floor, walls or any computer generated object located in the scene that has flat surfaces.

In addition the present invention can be applied simultaniously to a multi-camera studio.

Thus, by capturing the position of the object/actor, the camera parameters (especially the camera position and point of view), the object/actor foreground image, it is possible to calculate a reflection image. Because reflection is caused by light rays that are starting from the object then reflecting from the surface to the camera one has to know all the parameters regarding the position of the object and the camera parameters, it is not possible to construct the reflection image if one of this parameters is missing. This is what makes the present system special since the systems captures both the object position and the camera parameters.

The present invention provides an apparatus for creating an artificial reflection of an actor, said apparatus comprising a main camera, an actor position tracking device a system for tracking camera parameters (x, y, z position, pan, roll, tilt, zoom, aspect ratio) and a transformation processor, said transformation processor comprising means for imaging said object from the position of the main camera, means for approximating the image of the actor to be a two dimensional image facing the camera and means for transforming the two dimensional image to produce a two

dimensional reflection on a surface adjacent to the actor, means for generating a substitute background image and means for combining the image of said actor, the two dimensional transformed reflection and the substitute background image into a combined video output in which both said image of said actor and the reflection of the actor are present in the combined video output thereby providing a realistic association of said actor with said substitute background image.

In the present invention the term actor is defined as including other foreground objects.

The invention also provides apparatus for creating an artificial reflection of an actor in which the transformation is a perspective transformation.

Alternatively the transformation is a geometrical transformation.

The present invention also provides apparatus for creating an artificial reflection of an actor as in which the actor is captured and separated from a background by chroma keying, edge detection, difference keying, luminance keying image triangulation and/or depth keying.

The present invention also provides a method of producing an artificial reflection of an actor, said method comprising the steps of:

(a) obtaining an image of the actor by means of a video camera;

(b) tracking the position of the actor relative to the camera;

(c) tracking the camera parameters;

(d) transforming the position of the actor by the step of :

i. processing the image of the actor formed by the video camera as a two dimensional image;

ii. transforming the two dimensional image of the actor to represent a reflection of the actor in a different plane to the plane of the two dimensional image of the actor, said different plane representing a ground plane as defined on which the reflection is to be present; and

(e) combining the video image of the actor, the transformed reflective image and a virtual background image to provide a combined video output comprising a real actor, a virtual reflection of said actor and a virtual reality background.

The invention also provides a method of producing an artificial reflection of an actor in which the transformation of the two dimensional image of the actor is a perspective transformation.

Alternatively, the transformation of the two dimensional image of the actor is a geometrical transformation.

The invention also provides a method of producing an artificial reflection of an actor in which the image of the actor is captured and separated from a background by choma keying, edge detection, difference keying luminance keying, image triangulation and/or depth keying.

The term ground plane is defined as any plane adjacent to the actor which could include walls or computer generated objects.

In order to add an artificial reflection to a video image, the foreground video must be captured. It will then be composed into the image in a method that is described below.

The present invention will now be described, by way of example with reference to the accompanying drawings in which :

Figure 1 shows diagrammatically apparatus illustrating production of a flat reflection of a foreground object;

Figure 2 shows a first embodiment illustrating in greater detail a first apparatus and method for production of a reflection of a foreground object as illustrated in Figure 1; and

Figure 3 shows a second embodiment illustrating in greater detail a second apparatus and method for production of a reflection of a foreground object as illustrated in Figure 1.

In order to capture the chosen foreground object(s), the object must first be captured by a video camera. In order to capture and separate the object from its background, the system must use a keying method. The keying method is preferably chroma keying normally used in virtual studio, but can also be done using edge detection, difference keying, luminance keying, image triangulation and depth keying.

In order to introduce an artificial reflection of an object in a virtual studio environment, the video image should be segmented into three parts; the object as it appears in the original video image, the reflection as a mixed foreground and background image and the rest of the video image as background image. The level of mixing the reflection image with the background can varied by a separated control unit that can be adjusted

according to original light intensity or the distance which the light ray travels from the object to the capturing camera, or any method suitable to form the proper lighting intensity of the reflection image. The level of mixing can also varied inside the reflection image according to lighting condition, position of the original point in the actor or/and object two dimensional image and intensity map design by the operator simulating surfaces with varied reflection coefficients. The background image can be computer generated in cases of a virtual studio scene and can be composed of a number of sources, such as graphics or video images.

In order to calculate the proper shape and texture of the artificial reflection cast by the object as should be seen from the point of view of the video camera. The method proposed in this application for calculating the artificial reflection is based on the manipulation of the original foreground object image. In this application we approximate the foreground image of the actor or/and object to be a two dimensional image facing the shooting camera.

The reflection image calculation is constructed from several steps:

First, detecting the actor or/and object position, this can be done by several position detection methods like the one presented in International Patent Application No. WO98/34410 "Virtual Studio Position Sensing System".

Second, detecting the camera parameters (x,y,z position, pan, roll, tilt, zoom, aspect ratio), this can be done by any camera parameters detection system, like the one presented in International Patent Application No. WO95/30312 "Improved Chroma Keying System".

Third, keying of the foreground object from the rest of the video image, using any keying technique, preferably chroma keying which is the conventional keying method in virtual studios.

Fourth, producing the reflection image by calculating a geometrical transformation of the foreground image according to the object position and the camera parameters. The calculation of the reflection image by geometrical transformation is aplicable due to the assumption that the object is presented by a two dimentional plane facing the shooting camera.. With out this assumption there is a need to calculate for each point in the foreground object the exact position in space and perform a separate transformation calculation for each point.

Fifth, combining the foreground actor or/object with the reflection image to the background image.

With reference now to Figure 1, the apparatus 10 comprises a foreground actor 12, a chroma key colour background 14 and floor section 16. A main video camera 18 is situated to film the actor 12 against the chroma key coloured background which may, for example, be a blue colour.

In Figure 1 a reflection 20 of the actor 12 is shown which in the normal image will be present in front of the actor showing the reflection of the actor, or foreground object of the floor 16.

In a virtual studio comprising, for example, a blue screen studio the reflection 20 does not appear, since the floor is not reflected or has very poor reflection properties. Thus, an artificial reflection should be

constructed. Figure 1 shows how the reflection should be in a real image. Directed toward the camera with shape dependant on the object/actor position and the camera parameters. Figure 1 does not resemble a true image of combined object and reflection image, since it is a side view.

With reference to Figure 2, a first apparatus is shown which relates to a more general technique which keys the foreground object out from the background image and then performs a transformation to calculate the reflection image. Then the object/actor+the reflection+the artificial background are summed to form to output image. The apparatus comprises the main camera 18, an actor/object position tracking device 200 such as described in co-pending International Patent Application No. 98/34410 (Virtual Camera + LED), a chroma keyer 202 such as manufactured by ULTIMATTE (Registered Trade Mark).

The device 200 and keyer 202 are both connected to a transformation processor 204 which also has inputs from a camera parameter tracking device 206.

The output of transformation processor 204 is connected to a combiner 208 in which the output of keyer 202 is combined with the output of the processor to provide a combined image which includes the reflection 20 provided by the transformation process.

This combined output from combiner 208 then requires to be further combined in a combiner 210 with a background image provided by a camera or computer 212 which provides the "virtual" background image which when combined with the output of combiner 208 provides the composite video output via output circuit 2143.

The key element to the invnetion is that by knowledge of the position of the actor/object 200 and the camera tracking device 206 and by consideration that the object comprises a flat surface the reflector can be accurately processed in relatively simple combiner circuits.

With reference to Figure 3, an alternative circuit is shown. In this second example (which is possibly the more practical method), the image from the main camera is combined with the transformation of the same image (corresponding to the reflection transformation). The integration is done in a specific way. The reflection image is integrated into the original image in areas where it is shown that the foreground object does not appear. This can be done, since we have general knowledge of the object dimension and we know its position and the camera parameters. After making this integration a chroma keyer is used (by that saving the object keyer used in the above first example) which also adds the background image. This circuit is similar to that of Figure 2 and units within Figure 3 which perform the same or similar function to those in Figure 2 are given the same reference numerals.

In Figure 3 the transformation processor 204 operates directly on the output of the main camera 18 without the signal having been separated into foreground and background.

In Figure 3 the combiner circuit 210 of Figure 2 is replaced by a more complex combiner unit which combines the function of both a combiner and a chroma key circuit. Thus, the function of units 202 and 210 in Figure 2 are combined into a single unit 216 in Figure 3.

The output of chroma key combiner 216 represents the video output 214.

In the Second specific embodiment presented by Figure 3, the system is constructed by a Chroma key studio, capturing video camera, position detection system to capture the position of the actor or/and object, Camera parameters detecting system, processor to compute the geometrical transformation, computer of video source for the generation of the background image and a chroma keyer. The generation of reflection image for the present embodiment is constructed by the following steps:

First, an image of the actor or/and objects is captured in a chroma key studio.

Second, a selected part of the image that includes the actor or object is then transformed by geometrical transformation performed in the processor using actor or object position and the camera parameters.

Third, the transformed image is then mixed with the original image in a proper way.

Fourth, the mixed image is then combined with the background image using a chroma key combiner.

In a specific embodiment the geometrical transformation to form the reflection image is a perspective transformation.

In another embodiment the geometrical transformation to form the reflection image can be any geometrical transformation.

CLAIMS

1. Apparatus for creating an artificial reflection of an actor, said apparatus comprising a main camera, an actor position tracking device. a system for tracking camera parameters (x, y, z position, pan, roll, tilt, zoom, aspect ratio), and a transformation processor, said transformation processor comprising means for imaging said object from the position of the main camera, means for approximating the image of the actor to be a two dimensional image facing the camera and means for transforming the two dimensional image to produce a two dimensional reflection on a surface adjacent to the actor, means for generating a substitute background image and means for combining the image of said actor, the two dimensional transformed reflection and the substitute background image into a combined video output in which both said image of said actor and the reflection of the actor are present in the combined video output thereby providing a realistic associate of said actor with said substitute background image.

2. Apparatus for creating an artificial reflection of an actor, as claimed in Claim 1, in which the transformation is a perspective transformation.

3. Apparatus for creating an artificial reflection of an actor, as claimed in claim 1, in which the transformation is a geometrical transformation.

4. Apparatus for creating an artificial reflection of an actor, as claimed in any one of claims 1 to 3, in which the actor is captured and separated from a background by chroma keying, edge detection,

difference keying, luminance keying image triangulation and/or depth keying.

5. A method of producing an artificial reflection of an actor, said method comprising the steps of:

(a) obtaining an image of the actor by means of a video camera;

(b) tracking the position of the actor relative to the camera;

(c) tracking the camera parameters;

(d) transforming the position of the actor by the step of :

i. processing the image of the actor formed by the video camera as a two dimensional image;

ii. transforming the two dimensional image of the actor to represent a reflection of the actor in a different plane to the plane of the two dimensional image of the actor, said different plane representing a ground plane as defined on which the reflection is to be present; and

(e) combining the video image of the actor, the transformed reflective image and a virtual background image to provide a combined video output comprising a real actor, a virtual reflection of said actor and a virtual reality background.

6. A method of producing an artificial reflection of an actor as claimed in claim 5 in which the transformation of the two dimensional image of the actor is a perspective transformation.

7. A method of producing an artificial reflection of an actor, as claimed in claim 5, in which the transformation of the two dimensional image of the actor is a geometrical transformation.

8. A method of producing an artificial reflection of an actor, as claimed in any one of claims 5 to 7, in which the image of the actor is captured and separated from a background by chroma keying, edge detection, difference keying, luminance keying, image triangulation and/or depth keying.

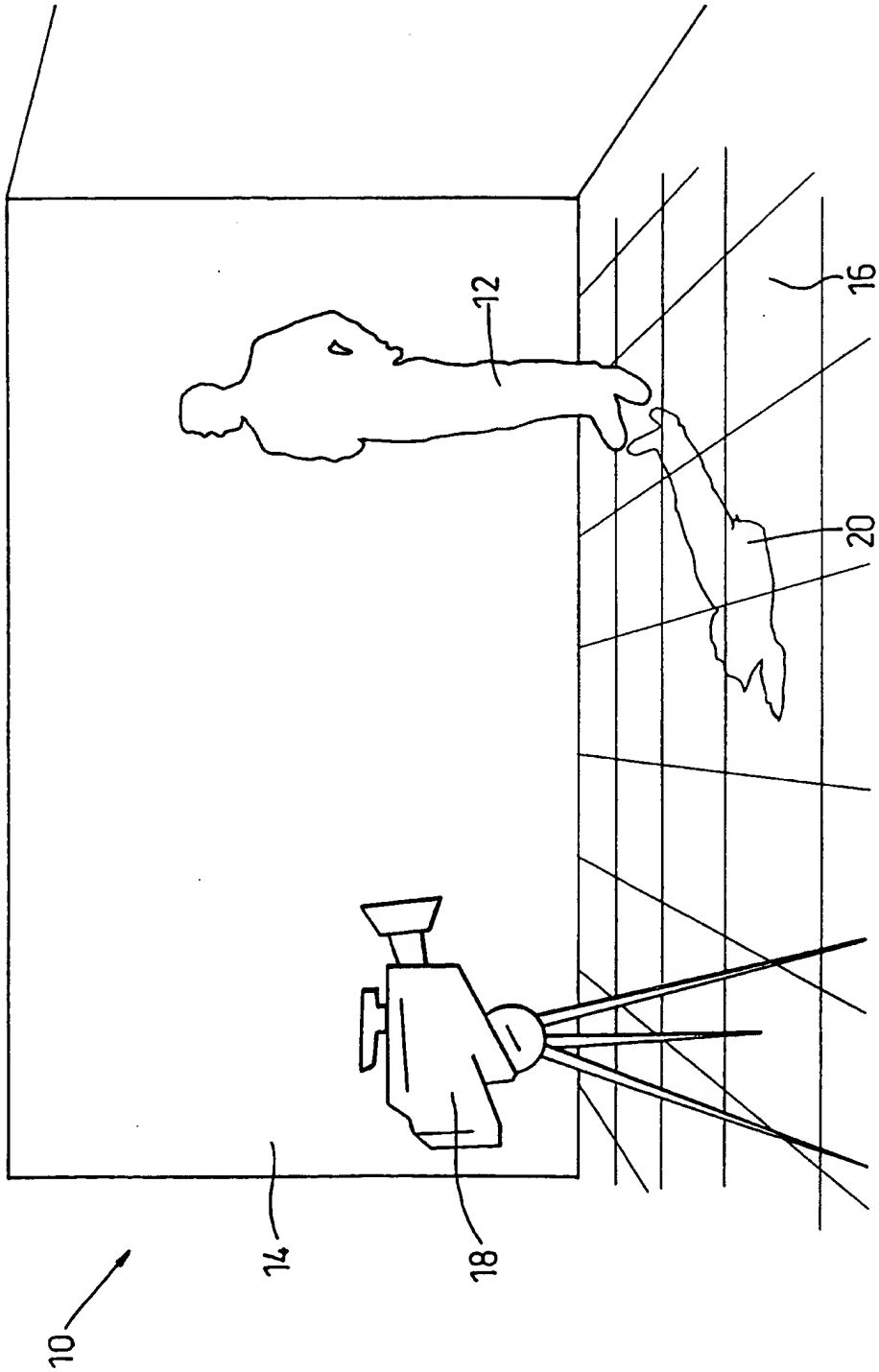
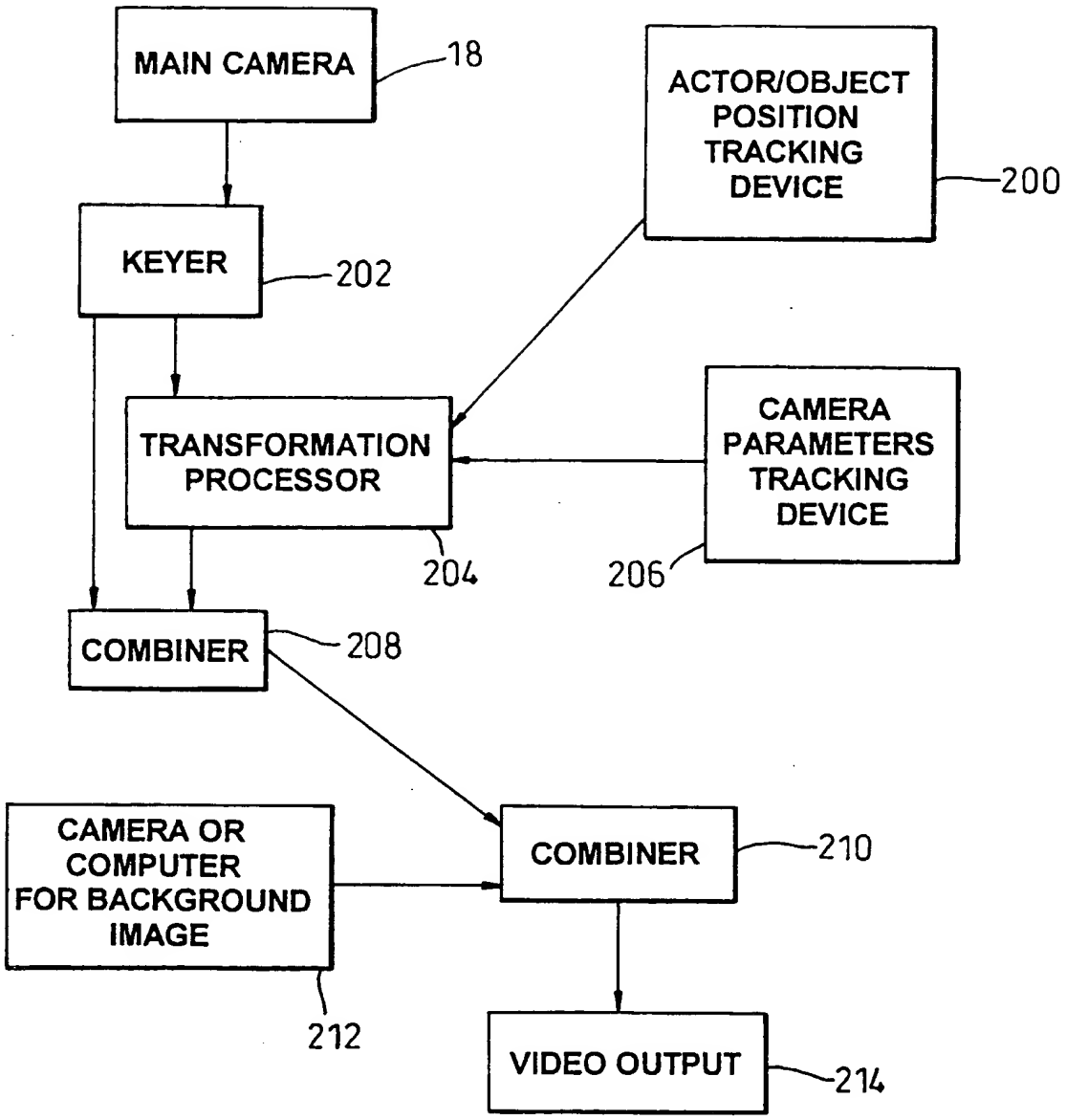


Fig. 1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KEYER
202
TRANSFORMATION PROCESSOR
204
CAMERA PARAMETERS TRACKING DEVICE
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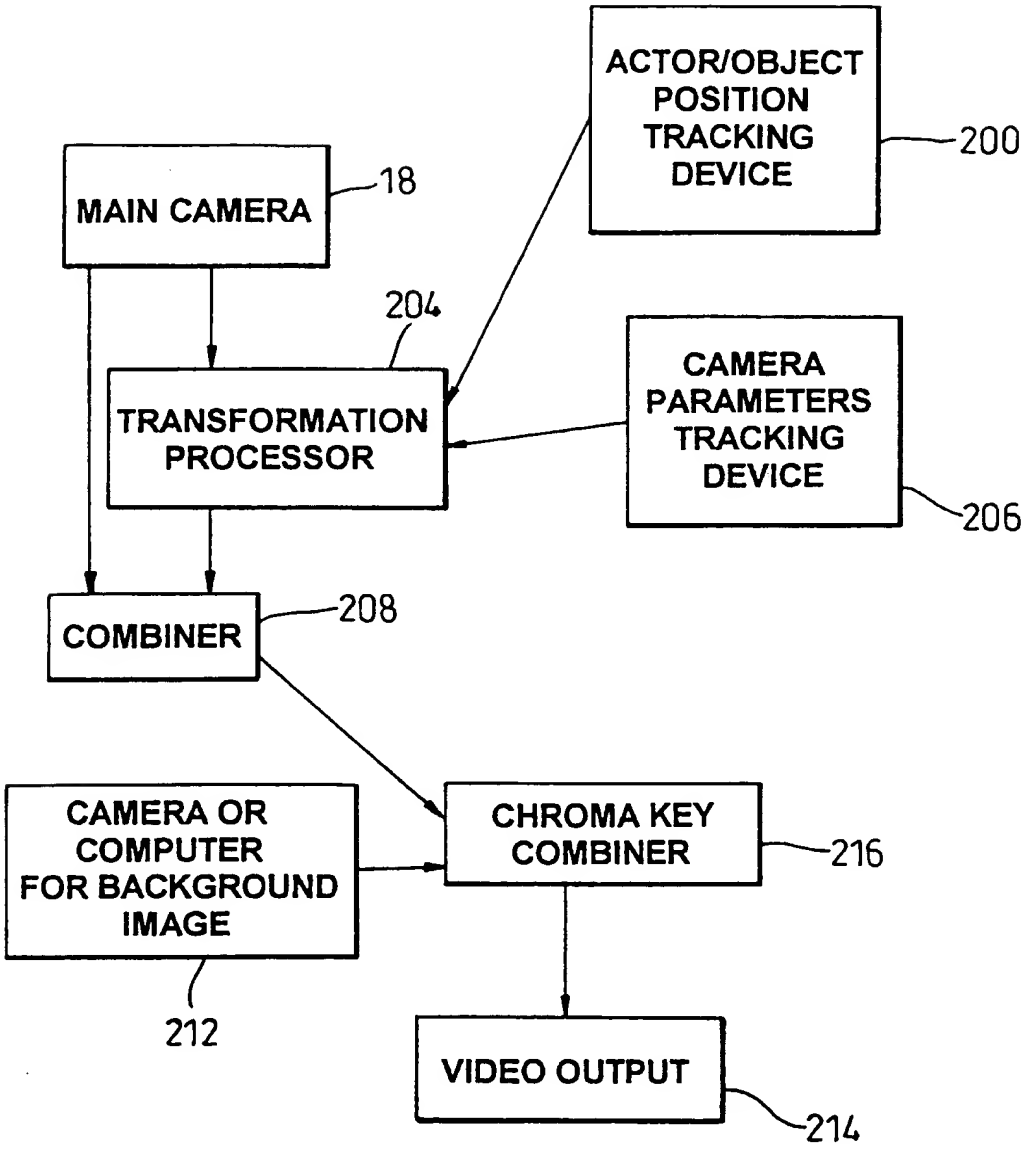
COMBINER
208
CAMERA OR COMPUTER FOR BACKGROUND IMAGE
212
COMBINER
210
VIDEO OUTPUT
214

Fig. 2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200
MAIN CAMERA
18
204
TRANSFORMATION PROCESSOR
CAMERA PARAMETERS TRACKING DEVICE
206
COMBINER
208
CAMERA OR COMPUTER FOR BACKGROUND IMAGE
212
CHROMA KEY COMBINER
216
VIDEO OUTPUT
214

Fig. 3

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/GB 00/01282

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N5/222 H04N5/272

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	HUGHES D: "VIRTUAL STUDI TECHNOLOGY. THE 1996 EUROVISION SONG CONTEST" EBU REVIEW- TECHNICAL,BE,EUROPEAN BROADCASTING UNION. BRUSSELS, no. 268, 1 June 1996 (1996-06-01), pages 7-13, XP000598994 ISSN: 0251-0936 figure 1 page 10, right-hand column, line 14 - line 54 ---	1,5
A	WO 97 28654 A (RT SET LTD) 7 August 1997 (1997-08-07) page 7, line 14 -page 9, line 21 -----	1,5

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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5 July 2000	14/07/2000

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